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MATHEMATIK

ZUR LAPLACE-TRANSFORMATION. II.

Von V. S. IGNATOVSKIJ (W. v. IGNATOWSKY), korrespondierendem Mitglied der Akademie

Diese Notiz dient als Fortsetzung einer früheren (1) unter denselben Titel. Der Zweck ist die Integration der Gleichung:

$$\frac{1}{c^2}\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} + c_1\frac{\partial u}{\partial t} + a_1\frac{\partial u}{\partial x} + mu = \varphi(x,\ t), \tag{1}$$

für

$$0 < x < l \quad \text{und} \quad t > 0, \tag{2}$$

unter gewissen Rand- und Anfangsbedingungen auszuführen. Wir setzen

$$u(x,\ t) = w(x,\ t)\,e^{-\mu t - \nu x} \tag{3}$$

und erhalten dann statt (1)

$$a\frac{\partial^2 w}{\partial t^2} - \frac{\partial^2 w}{\partial x^2} + \rho^2 w = \psi(x,\ t) = \varphi(x,\ t)\,e^{\mu t + \nu x}, \tag{4}$$

mit

$$a = \frac{1}{c^2}; \qquad \rho^2 = m - \frac{c_1^2 c^2}{4} + \frac{a_1^2}{4}; \quad a > 0^*, \tag{5}$$

$$\mu = \frac{c^2 c_1}{2}; \quad \nu = -\frac{a_1}{2}. \tag{6}$$

Wir führen nun folgende Bezeichnungen ein:

$$w(+0,\ t) = w_0(t); \quad w(l-0,\ t) = w_l(t); \tag{7}$$

$$\frac{\partial w(x,\ t)}{\partial x}_{x\to 0} = h_1(t); \quad \frac{\partial w(x,\ t)}{\partial x}_{x\to l} = h_2(t); \tag{8}$$

$$w(x,\ +0) = f_1(x); \quad \frac{\partial w(x,\ t)}{\partial t}_{t\to 0} = F_1(x); \tag{9}$$

und

$$u(+0,\ t) = u_0(t); \quad u(l-0,\ t) = u_l(t); \tag{10}$$

$$\frac{\partial u(x,\ t)}{\partial x}_{x\to 0} = h_0(t); \quad \frac{\partial u(x,\ t)}{\partial x}_{x\to l} = h_l(t); \tag{11}$$

$$u(x,\ +0) = f(x); \quad \frac{\partial u(x,\ t)}{\partial t}_{t\to 0,} = F(x). \tag{12}$$

* Auch in der vorigen Notiz (1) muss $\frac{1}{c^2} = a > 0$ statt $c > 0$ stehen.

Aus (7)—(12) folgt nun:

$$w_0(t) = u_0(t)\, e^{\mu t}; \quad w_l(t) = u_l(t)\, e^{\mu t + \nu l}; \tag{13}$$

$$h_1(t) = e^{\mu t}\{h_0(t) + \nu u_0(t)\}; \quad h_2(t) = e^{\mu t + \nu l}\{h_l(t) + \nu u_l(t)\}; \tag{14}$$

$$f_1(x) = f(x)\, e^{\nu x}; \quad F_1(x) = e^{\nu x}\{F(x) + \mu f(x)\}. \tag{15}$$

Wir wenden jetzt auf (4) die Laplace-Transformation an und zwar in bezug auf die Zeit t und wegen (3) von $t = 0$ bis $t = \infty$. Es folgt dann aus (4):

$$\frac{d^2 r(x,\, z)}{dx^2} - \frac{1}{c^2}(z^2 + \varrho^2 c^2)\, r(x,\, z) = \gamma(x,\, z) - \frac{z}{c^2} f_1(x) - \frac{1}{c^2} F_1(x), \tag{16}$$

wobei $r(x,\, z)$ resp. $\gamma(x,\, z)$ die Unterfunktionen von $w(x,\, t)$ resp. $\psi(x,\, t)$ bedeuten. Infolge der Ausführungen, die wir hier nicht anführen können, erhalten wir für (16) vier verschiedene Lösungen*, wobei

$$\psi(x,\, t), \quad f_1(x) \quad \text{und} \quad F_1(x) \tag{17}$$

immer als bekannt vorausgesetzt sind und von den übrigen vier Grössen in (7)—(9) je zwei gegeben sein müssen und zwar in den folgenden vier Kombinationen:

$$\left.\begin{array}{ll} \text{a)}\ w_0(t),\ w_l(t); & \text{b)}\ h_1(t),\ w_l(t); \\ \text{c)}\ w_0(t),\ h_2(t); & \text{d)}\ h_1(t),\ h_2(t). \end{array}\right\} \tag{18}$$

Wir beschränken uns hier auf den Fall a) und erhalten:

$$r(x,\, z) = \frac{K_0(z)\, \mathrm{sh}\left\{\frac{\omega_1 (l-x)}{c}\right\}}{\mathrm{sh}\,\frac{l\omega_1}{c}} + \frac{K_l(z)\, \mathrm{sh}\,\frac{x\omega_1}{c}}{\mathrm{sh}\,\frac{l\omega_1}{c}} + M_1(x,\, z) \tag{19}$$

mit

$$M_1(x,\, z) = \frac{\mathrm{sh}\,\frac{x\omega_1}{c}}{\frac{\omega_1}{c}\,\mathrm{sh}\,\frac{l\omega_1}{c}} \int_0^l \mathrm{sh}\,\frac{\omega_1 (l-y)}{c} \cdot D_1(y)\, dy -$$

$$- \frac{1}{\frac{\omega_1}{c}} \int_0^x \mathrm{sh}\,\frac{\omega_1 (x-y)}{c} \cdot D_1(y) dy; \qquad \omega_1 = \sqrt{z^2 + \varrho^2 c^2} \tag{20}$$

und

$$D_1(x) = \gamma(x,\, z) + \frac{z}{c^2} f_1(x) + \frac{1}{c^2} F_1(x), \tag{21}$$

wo $K_0(z)$ und $K_l(z)$ bedeuten die Unterfunktionen von $w_0(t)$ und $w_l(t)$. Nun ergibt sich aus (20)

$$M_1(0,\, z) = M_1(l,\, z) = 0, \tag{22}$$

und deshalb wegen (19)

$$r(0,\, z) = K_0(z); \quad r(l,\, z) = K_l(z), \tag{23}$$

* Bezüglich anderer Lösungen kommen wir später zurück.

woraus wir ersehen, dass dies dem Fall a) entspricht.

Wegen (22) können wir nun (20) in eine Fourier-Reihe nach $\sin \frac{\pi n x}{l}$ zerlegen und erhalten

$$M_1(x,\ z) = \sum_{n=1}^{\infty} \frac{\gamma_n \sin \frac{\pi n x}{l}}{\left(\frac{\pi n}{l}\right)^2 + \omega_1^2 c^2};\quad 0 \leqslant x \leqslant l \tag{24}$$

mit

$$\gamma_n = \frac{2}{l} \int_0^l D_1(x) \sin \frac{\pi n x}{l}\, dx, \tag{25}$$

weshalb wir annehmen wollen, dass

$$D_1(x) = \sum_{n=1}^{\infty} \gamma_n \sin \frac{\pi n x}{l} \tag{26}$$

ist, welche Gleichung bekanntlich unter ziemlich weitgehenden Bedingungen für $D_1(x)$ gelten wird, wo jetzt aber im allgemeinen $0 < x < l$ stehen muss.

Wir setzen nun (24) in (19) ein und gehen dann zur Oberfunktion über. Hierbei beachten wir, dass

$$\frac{K_0(z) \operatorname{sh} \frac{\omega_1 (l-x)}{c}}{\operatorname{sh} \frac{l \omega_1}{c}} = -\frac{\partial}{\partial x} \frac{\operatorname{ch} \frac{\omega_1 (l-x)}{c}}{\frac{\omega_1}{c} \operatorname{sh} \frac{\omega_1 l}{c}} \tag{27}$$

sein wird [mit einer entsprechenden Gleichung für das zweite Glied in (19)] und erhalten dann, falls wir hinterher noch die Beziehungen (3), (13)—(15) einführen, d. h. zu den Funktionen $u(x,\ t)$ und (10)—(12) übergehen*:

$$u(x,\ t) = -\frac{2ce^{-\nu x}}{l} \frac{\partial}{\partial x} \left[\sum_{n=1}^{\infty} \frac{\cos \frac{\pi n x}{l}}{\alpha_n} \int_0^t \left\{ u_0(t-y) - \right.\right.$$

$$\left. - u_l(t-y)\,(-1)^n e^{\nu l} \right\} c^{-y\mu} \sin(cy\alpha_n)\, dy +$$

$$\left. + ce^{-\nu x} \sum_{n=1}^{\infty} \frac{\sin \frac{\pi n x}{l}}{\alpha_n} \int_0^t e^{-y\mu} \gamma^{\circ}_{n,1}(t-y) \sin(cy\alpha_n)\, dy \right] +$$

$$+ e^{-\mu t - \nu x} \sum_{n=1}^{\infty} \sin \frac{\pi n x}{l} \left\{ \gamma^{\circ}_{n,2} \cdot \cos(ct\alpha_n) + \right.$$

$$\left. + \frac{c}{\alpha_n} \gamma^{\circ}_{n,3} \cdot \sin(ct\alpha_n) \right\};\quad \alpha_n = \sqrt{\varrho^2 + \left(\frac{\pi n}{l}\right)^2} \tag{28}$$

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* Es sei hier nebenbei bemerkt, dass wir auch in I den Übergang von (1) zu (4) anwandten.

mit

$$\gamma^{\circ}_{n,1}(t) = \frac{2}{l}\int_0^l e^{\nu x}\varphi(x,\ t)\sin\frac{\pi n x}{l}\,dx, \tag{29}$$

$$\gamma^{\circ}_{n,2} = \frac{2}{l}\int_0^l e^{\nu x} f(x)\sin\frac{\pi n x}{l}\,dx \tag{30}$$

und

$$\gamma^{\circ}_{n,3} = \frac{2}{l}\int_0^l e^{\nu x}\{F(x) + \mu f(x)\}\,dx. \tag{31}$$

Da nun (19) die Gleichung (16) befriedigt, so ersehen wir, unter Berücksichtigung der Laplace-Transformation, dass (28) die gesuchte Lösung der Gleichung (1) darstellt. Die Eindeutigkeit wird durch das Theorem von Lerch gewärleistet.

Bezüglich der Funktionen $u_0(t)$, $u_l(t)$ und $f(x)$, $F(x)$ sei dasselbe bemerkt, wie in der vorigen Notiz (1), nur dass hier für die beiden letzten Funktionen noch das Verschwinden für $x > l$ hinzukommt.

Analog, wie in der vorigen Notiz (1), erhalten wir auch hier

$$w_0(0) = f_1(0) \text{ resp. } u_0(0) = f(0) \tag{32}$$

und

$$w_l(0) = f_1(l) \text{ resp. } u_l(0) = f(l). \tag{33}$$

Dies kann man z. B. folgendermassen nachweisen. Wir wenden auf (1) die Laplace-Transformation in Bezug auf x an und zwar von $x = 0$ bis $x = l$, und erhalten dann eine Lösungsform, die uns die hin- und hergehenden Wellen hervortreten lässt und welche mit Anwachsen der Zeit aus immer mehr Glieder bestehen wird.

Für $x=0$ und $tc < l$ haben wir dann:

$$\begin{aligned} w_0(t) - f_1(tc) = &-c\nu t\int_0^{tc} f_1(y)\, I_1(\nu\sqrt{y^2 - t^2c^2})\,dy + \\ &+\frac{1}{c}\int_0^{tc} F_1(y)\, I_0(\nu\sqrt{y^2 - t^2c^2})\,dy - c\int_0^t h_1(t-y)\, I_0(i\nu cy)\,dy + \\ &+c\int_0^t dy\int_0^{yc}\psi(s,\ t-y)\, I_0(\nu\sqrt{s^2 - y^2c^2})\,ds;\quad tc < l, \end{aligned} \tag{34}$$

wo $I_0(x)$ resp. $I_1(x)$ Besselsche Funktionen mit imaginärem Argument der nullten, resp. ersten Ordnung darstellen.

Aus (34) folgt dann für $t = 0$ die Gleichung (32).

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PHYSICS

ON MAGNETIC VISCOSITY AT DIFFERENT POINTS OF THE MAGNETIZATION CURVE

By A. MITKEVIČ (MITKEVITCH)

(Communicated by V. Th. Mitkevitch, Member of the Academy, 28. III. 1936)

1. As Ewing has stated (1), in weak fields magnetic viscosity depends on the time interval during which the previous magnetic force was maintained constant, *i. e.* magnetic viscosity depends on magnetic history. On the other hand, Preisach (2) when investigating magnetic viscosity, did not obtain this dependence and, as he remarked, his experimental data, because of this fact, are not in agreement with Ewing's results. However, I have shown (3,4,5,) that in certain cases magnetic viscosity in iron depends to a great extent on magnetic history, and sometimes even the sign of the change of magnetic induction caused by magnetic viscosity depends on the time during which the previous magnetic force was kept constant (6).

It is the object of the present paper to show under what condition the effect of magnetic history on subsequent manifestations of magnetic viscosity can be most easily observed and, incidentally, to point out in what portion of the magnetization curve magnetic viscosity is most marked.

2. One of the previously described iron rings (6) made of shellac coated iron wire 0. 1 mm in diameter, with coercive force $H_c = 14$ oersteds was investigated. As shown by calculation, in this case eddy currents delay became practically quite imperceptible after one thousandth part of a second from the instant of changing magnetic force. Search coil and magnetizing coil were wound on the investigated ring. Magnetization curve was obtained by the method of reversals. The investigated iron being brought into a cyclic magnetic state, magnetic force $-H_m$ was maintained constant during time interval T_1, then the magnetizing current was reversed and a certain time interval θ afterwards the search coil was connected to the galvanometer (fluxmeter type) (6). That is to say, magnetic force—H_m was constant during the time T_1 and after a measured interval of time θ, from the instant of changing magnetic force from $-H_m$ to $+H_m$ the search coil was connected to the galvanometer.

The time necessary for the magnetizing cnrrent to attain a constant value was computed to be negligibly small, but was nevertheless checked up by changing the resistance of the circuit of magnetizing coil 3 times, and this did not change the observed magnetic viscosity even in the case of maximum permeability. To get rid of the effects of inconstancy of the magnetizing current, the

circuit of the magnetizing coil was carried out without any sliding contacts only mercury or soldered contacts being used. As was found, the heat generated by the magnetizing current did not affect the observed manifestations of magnetic viscosity under the conditions of the present work. Together with this, precautions were taken against the influence of the fluctuations of earth magnetic field. However, a thick magnetic screen of cast iron when used to shield the investigated iron ring did not change in any way the data obtained. The specimen tested, the galvanometer and the circuit of the search coil were surrounded by shields at ground potentials, but as was shown by an examination, this shielding became necessary only in the case of high-frequency oscillator being in action in the same room.

3. Table 1 presents the manifestations of magnetic viscosity with different values of magnetic force $+H_m$. Time interval T_1 being equal to 30 seconds. In the second column are given the corresponding values of magnetic induction $+B_m$. The results given in the third column were obtained in the case of $\theta=0.25$ sec., *i. e.* the search coil being connected to the galvanometer after 0.25 second from the instant of reversing magnetizing current. Similarly, the data given in the other columns were obtained this time interval θ being equal to 0.5, 1, 5 and 10 sec.

Table 1

Oersteds	Gausses					
		Manifestations of magnetic viscosity				
H_m	B_m	θ=0.25 sec.	θ=0.5 sec.	θ=1 sec.	θ=5 sec.	θ=10 sec.
1	65	0.20	0.16	0.13	0.07	0.06
5	360	1.26	1.00	0.86	0.51	0.36
12	3 000	14.20	11.60	9.72	6.00	4.26
15	6 750	21.00	16.60	13.60	7.80	5.40
37	11 100	3.44	2.96	2.36	0.96	0.60
65	12 600	0.80	0.74	0.40	—	—

The most interesting feature of the observed results is the fact that the manifestations of magnetic viscosity reaching maximum on the steepest part of the magnetization curve, are falling off exponentially with the time, having almost the same modulus of decay, at different values of magnetic force H_m, *i. e* at different values of the differential magnetic permeability.

4. In the Table 2 are given the experimental data obtained with different values of magnetic force $+H_m$, when connecting search coil to the galvanometer after 0.25 second from the instant of reversing magnetizing current, *i. e.* $\theta=0.25$ second, time intervals T_1, during which $-H_m$ was kept constant, being equal to 0.25 second or 30 seconds. From the first to the fourth horizontal row the constant is 0.005 gauss per 1 mm scale deflection, for the fifth row 0.02 gauss per 1 mm, for the sixth row 0.2 gauss per 1 mm, and for the seventh and eighth rows 0.04 gauss per 1 mm. Beginning with the fifth horizontal row, in the second, third and fourth columns, we give in brackets the coefficients for reducing the observed deflections of the galvanometer to the same sensitivity as that of the first four rows.

Table 2

Oersteds H_m	Millimetres of scale deflection			Percentage
	Manifestations of magnetic viscosity		Difference between the values of the third and second column	
	T_1=0.25 sec.	T_1=30 sec.		
0.25	4.5	8.5	4	90
0.5	12.5	20	7.5	60
1	28	40	12	43
5	205	252	47	23
10	403 (×4)	435 (×4)	32 (×4)	8
15	101 (×40)	105 (×40)	4 (×40)	4
37	86 (×8)	86 (×8)	0	0
65	20 (×8)	20 (×8)	0	0

From Table 2 it may readily be seen that the effect of magnetic history on subsequent magnetic viscosity is most marked in very weak fields, becoming imperceptidle with the increase of magnetic force.

5. It is worth to point out several important characteristics of magnetic iscosity that can be inferred from a study of the given above tables. Firstly, he intensity of the effect of magnetic viscosity is not the same at different portions of the magnetization curve, reaching maximum at the steepest portion. Secondly, the change of magnetic induction caused by magnetic viscosity falls of exponentially with the time, having almost the same modulus of decay, at different values of the magnetic force, *i. e.* at different values of the differential permeability. Thirdly in certain cases, notwithstanding the comparatively large magnitude of the previous change of magnetic induction from $-B_m$ to $+B_m$, magnetic viscosity at $+B_m$ depends on the time T_1, during which $-B_m$ was constant. In other words, the investigated iron, when magnetic induction is being chaned from $-B_m$ to $+B_m$ «remembers» the process, quantitatively quite insignificant, that was taking place with the time at $-B_m$. Fourthly, magnetic viscosity in the initial section of the magnetization curve differs qualitatively from those in the second and third sections, being far more affected by the previous time intervals, *i. e.* by magnetic history. These conclusions are in good agreement with my previous paper ([6]).

Taking into account that there are, as it is known, different processes of changing magnetic induction corresponding to each sections of the magnetization curve, certain qualitative difference in the phenomenon of magnetic viscosity for the initial steep and third portion could be expected.

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CHEMIE

ÜBER DIE IRIDIUMBESTIMMUNG MITTELS KALIUMFERROCYANID-TITRATION

Von A. A. GRÜNBERG und J. L. MICHELIS

(Vorgelegt von N. S. Kurnakov, Mitglied der Akademie, d. 27. III. 1936)

Vor einigen Jahren hat der eine von uns gemeinsam mit B. W. Ptizyn neuartige volumetrische Methoden zur Bestimmung des vier- und dreiwertigen Iridiums ausgearbeitet [1]. Es wurde dabei gezeigt, dass sich das vierwertige Iridium in Form von $Me_2[IrCl_6]$ mittels einer Lösung des Mohr'schen Salzes quantitativ potentiometrisch titrieren lässt.

Es war von Interesse auch einige andere Reduktionsmittel, die eine quantitative massanalytische Bestimmung des vierwertigen Iridiums gestatten, aufzufinden. Solch ein Reduktionsmittel fanden wir in gelbem Blutlaugensalz. Ebenso wie das Salz von Mohr erlaubt auch das gelbe Blutlaugensalz das vierwertige Iridium, sowohl per se, wie auch in Gegenwart von $Me_2[PtCl_6]$ bzw. $Me_3[RhCl_6]$ in exakter Weise potentiometrisch zu bestimmen.

Als Untersuchungsobjekt wurde ein Hexachloriridiat $(NH_4)_3[IrCl_6]$-haltiges Präparat des Hexachloroirideats $(NH_4)_2[IrCl_6]$ benutzt. Dessen Prozentgehalt an Ir^{IV} wurde einerseits mittels einer titrierten Lösung des Mohrschen Salzes (nach A. A. Grünberg und B. W. Ptizyn), andererseits mittels einer eingestellten $K_4[Fe(CN)_6]$-Lösung in üblicher Weise potentiometrisch bestimmt. Der Titer beider Titrierflüssigkeiten wurde visuell auf manganometrischem Wege ermittelt. Die erhaltenen Resultate sind in nachfolgenden Tabellen zusammengestellt.

Tabelle 1

Titration mittels Mohr'schen Salzes

Einwage des Ir-Salzes in g	Titrierflüssigkeit in cm^3	Ir^{IV}-Gehalt in %
0.2412	6.85	42.29
0.2501	7.95	42.27
0.3147	10.05	42.07
	Mittel . . .	42.21%

Tabelle 2

Titration mittels $K_4[Fe(CN)_6]$

Einwage des Ir-Salzes in g	Titrierflüssigkeit in %	Ir^{IV}-Gehalt in %
0.2145	4.65	42.27
0.1915	4.15	42.08
0.2054	4.45	42.07
0.2420	5.25	42.13
0.2421	5.25	42.11
	Mittel . . .	42.13%

Tabelle 3

Titration mittels $K_4[Fe(CN)_6]$ in Gegenwart von $K_2[PtCl_6]$

Einwage des Ir-Salzes in g	Einwage des $K_2[PtCl_6]$ in g	Titrierflüssigkeit in cm³	Ir^{IV}-Gehalt in %
0.2670	0.4142	5.75	41.82
0.2465	0.3384	5.35	42.15
0.2375	0.3975	5.15	42.11
		Mittel . .	42.03%

Tabelle 4

Titration mittels $K_4[Fe(CN)_6]$ in Gegenwart von $(NH_4)_3[RhCl_6]$

Einwage des Ir-Salzes in g	Einwage des $(NH_4)_3[RhCl_6]$ in g	Titrierflüssigkeit in cm³	Ir^{IV}-Gehalt in %
0.3582	0.1354	7.75	42.04
0.2933	0.1432	6.35	42.02
		Mittel . . .	42.03%

Es ist ersichtlich, dass sich Ir^{IV} in Form von $[IrCl_6]''$ mittels $K_4[Fe(CN_6)]$ ebenso genau bestimmen lässt, wie mittels des Salzes von Mohr. Die unbedeutenden Schwankungen des Ir^{IV} -Gehalts bleiben immer in den Genauigkeitsgrenzen der Methode. Um grössere Genauigkeit zu erzielen muss man entweder grössere Einwagen benutzen, oder mit einer Mikrobürette arbeiten.

Die Titration mittels $K_4[Fe(CN_6)]$ wurde stets in schwefelsaurer Lösung ausgeführt. Die Potentialsprünge sind ganz deutlich ausgeprägt.

Um den Gang der Titrationskurve zu veranschaulichen, sei ein typisches Beispiel angeführt.

Tabelle 5

cm³	*mv*	Δ*mv*	cm³	*mv*	Δ*mv*	cm³	*mv*	Δ*mv*
0	862.5		3.5	663.0	0.32	4.4	598.0	1.8
1	731.0	1.32	4.0	643.0	0.40	4.5	561.5	3.65
2	702.0	0.29	4.2	626.0	0.85	4.6	538.0	2.35
3	679.0	0.23	4.3	616.0	1.0	4.7	525.5	1.25
						4.9	508.5	0.85

0.2054 g des Ir-Salzes wurden in 20 cm³ Wasser aufgelöst, mi 50 cm³ eine 25% H_2SO_4-Lösung versetzt und bei gewöhnlicher Temperatur mit $K_4[Fe(CN)_6]$ Lösung titriert.

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CHEMIE

UNTERSUCHUNG DER AUTOXYDATION UNGESÄTTIGTER KOHLENWASSERSTOFFE. I

Von P. PANJUTIN, L. HINDIN und O. VASILJEVA

(Vorgelegt von A. Favorskij, Mitglied der Akademie, d. 15. II. 1936)

1. EIN NEUES VERFAHREN FÜR QUANTITATIVE ANALYSE VON PEROXYDVERBINDUNGEN

Den heutigen Anschauungen gemäss, welche mit der klassischen Theorie von Bach-Engler in Einklang stehen, gehört in den Autoxydationsprozessen von ungesättigten Kohlenwasserstoffen* die massgebende Rolle den Peroxydverbindungen—den primären Oxydationsprodukten. Daraus wird auch das Bestreben der Forscher begreiflich, Struktur und Charakter dieser Verbindungen zu erschliessen, sowie auch Methoden für deren quantitative Analyse zu schaffen, die unerlässlich sind, um sich im Entwicklungsmechanismus der hier betrachteten Prozesse zurechtzufinden.

Alle bisher in Vorschlag gebrachten Verfaren zur quantitativen Bestimmung der Peroxyde, welche sich durch Bereitschaft zu mehr oder weniger leichtem Abspalten des «aktiven» Sauerstoffs kennzeichnen, beruhen auf dem Reduktionsprinzip und unterscheiden sich, im Grunde, durch die Beschaffenheit der anzuwendenden Reduktoren. Pechmann u. Vanino (1) machten den Vorschlag die Reduktion der Peroxyde mit Zinn-Dichlorid an saurem Medium vorzunehmen, Baeyer u. Villiger (2)—mit Wasserstoff in statu nascendi, Engler u. Weissberg (3)—mit indigotin-sulfosaurem Natron; Pictet (4)—mit Schwefligsäureanhydrid, Klason (5)—mit Cymol-Merkaptan, Rieche (6)—mit Titantrichlorid, Jule u. Wilson (7)—mit schwefelsaurem Eisenoxydul u. s. w. Endlich, haben ebenfalls Baeyer u. Villiger (8), ferner Clover, Richmond u. Houghton (9), Marks u. Morrell (10), Hymann u. Wagner (11), Lea(12), Pflug (13) u. a. m. allen übrigen Reduzenten den Jodwasserstoff vorgezogen. Die weiteren Stadien der Analyse lassen sich natürlicherweise auf die quantitative Bestimmung der aufgewandten Reduzenten zurückführen.

In vorliegender Mitteilung sind wir nicht in der Lage uns bei einer Kritik der bereits in Vorschlag gebrachten Verfahren und deren Anwendbarkeit auf bestimmte chemische Tatbestände aufzuhalten. Für die quantitative Analy-

* Wenngleich eine Reihe von aus vorliegender Mitteilung sich ergebender Folgerungen sich auch auf andere Klassen von organischen Verbindungen ausdehnen lässt, namentlich in erster Linie auf verschiedene Kohlenwasserstoffe, doch richten wir hier unsere Wahl gerade auf die ungesättigten Kohlenwassertoffe als unmittelbares Objekt unserer Versuche

se der Peroxydverbindungen, welche während der Autoxydation von ungesättigten Kohlenwasserstoffen entstehen, und insbesondere von solchen technischen Kombinationen wie, z. B., Cracking-Benzin* sind jedoch bei weitem nicht alle erwähnten Verfahren verwertbar. Und wiederum, von den anscheinend annehmbaren kann keines, in allen uns bekannten Modifikationen, den Anspruch erheben, in Anwendung auf die uns interessierenden Objekte, als eine quantitative Methode im vollen Sinne anerkannt zu werden. Die von uns ausgearbeitete Methode, zu deren Beschreibung wir hiermit übergehen, bietet gerade einen Versuch, ein solches Verfahren zur quantitativen Analyse der Peroxyde aufzustellen.

Von allen in Betracht kommenden Verfahren wählten wir aus verschiedenen Gründen die Reduktion der Peroxyde in den entsprechenden Verhältnissen mit Jodwasserstoff. Sogar die bei weitem nicht vollkommene Abänderung dieses Verfahrens, welche von Marks und Morrell vorgeschlagen wurde, ergab dreimal so grosse Werte für die Peroxyde in den Cracking-Benzinen gegenüber den Ergebnissen des Verfahrens von Jule u. Wilson ([5]).

Doch, um mittels des Jodwasserstoffverfahrens quantitative Resultate zu erzielen, war es notwendig, dasselbe von Grund aus umzugestalten und dabei ihm einen ganz neuen Inhalt mitzuteilen.

Hierin standen wir vor einer Reihe von Aufgaben. Erstens, galt es, das System Jodkalilösung—Benzin**, dessen mehrphasiger Bestand einigen Autoren bei Benutzung von wässeriger Jodkalilösung die quantitative Ausführung der Reaktion stark erschwerte, zu homogenisieren. Zweitens, kam es darauf an, das Jod zu berücksichtigen, welches gewöhnlich den ungesättigten Komponenten sich anlagert und dadurch der direkten Bestimmung sich entzieht, womit der Grundfehler der Methode behoben wäre. Ferner, war es notwendig, solche Bedingungen für die Reduktion der Peroxyde zu schaffen, welche deren ganze Mannigfaltigkeit der Reaktion nutzbar machten und dieser letzteren einen raschen Abschluss gewährleisten könnten.

Die erste Aufgabe lösten wir mittels Anwendung einer Spirituslösung von Jodkali und von konzentrierter Schwefelsäure. Die zweite gelang uns auf dem Wege einer Abschätzung der Mengen des von der Reaktion unberührt gebliebenen Jodkali anstelle des freien und des organisch gebundenen Jods. Endlich, versuchten wir der dritten Aufgabe beizukommen mittels Ansäuerung der Lösung mit starker Schwefelsäure anstatt der vorher ([14]) von uns benutzten Essigsäure.

Gegenwärtig hat die Methode bei uns folgende technische Ausbildung erhalten. Zu einer genau abgemessenen Menge von 2—5 ml (je nach dem Konzentrationsgrade der Peroxyde) des untersuchten Produkts, z. B. Benzin, werden in ein Glasgefäss mit gut angeschliffenem Pfropfen ebenso genau abgemessene 25 ml 4-prozentiger Spirituslösung von Jodkali und 0.5 ml chemisch reiner Schwefelsäure (spez. Gew. 1.84) zugesetzt. Die homogene Lösung wird vier Stunden im Dunkel stehen gelassen. Daneben wird in durchaus identischen Bedingungen ein Kontrollversuch angestellt mit 25 ml ebenderselben Jodkalilösung + 0.5 ml Schwefelsäure +5 ml Benzin von direkter Destillation, keine ungesättigten Verbindungen enthaltend. Hauptversuch und Kontrollversuch werden wiederholt. Nach Ablauf der erforderlichen Zeitspanne wird im Kontrollversuch das ausgeschiedene Jod mit Hyposulfit

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* Wir meinen hier nicht einzelne abgesonderte Peroxyde von Olefinen, aber deren Kombinationen mit ungesättigten Kohlenwasserstoffen, welche häufig sowohl in natürlichen als auch in technischen Produkten anzutreffen sind.

** Das in der grossen Mehrzahl unserer Versuche zugegen war.

titriert, während im Hauptversuch die Menge des an der Reaktion unbeteiligt gebliebenen Jodkali mittels Oxydation mit Ferrosalzen bestimmt wird. Zu diesem Zweck wird die Substanz des Hauptversuchs mit 100 ml destillierten Wassers extrahiert und zwar zweimal*, worauf die wässerige Schicht in einem Scheidetrichter jedesmal sorgfältig vom Benzin getrennt, in einen Messkolben übergeführt und auf ein Volumen von 250 ml gebracht wird. 50 ml dieser spirituswässerigen Jodkalilösung, welche eine gewisse Menge aufgenommenen freien Jods enthält, werden mit einer Pipette abgesondert und in einen Kolben mit rundem Boden von 200 ml Kapazität übergeführt. Der Kolben hat einen angeschliffenen Pfropfen, in welchen eine Ableitungsröhre eingelötet ist. Nach Hinzufügen von 5 ml 25-prozentiger Schwefelsäure, 2 g Eisen-Ammoniumalaun und 2—3 Stückchen Kalzit (zur Gleichmässigkeit des Siedens), wird der Kolben langsam erhitzt und das ausscheidende Jod mit 100 ml 10-prozentiger Jodkalilösung absorbiert. Dabei wird die Vorlage mit gestärktem Filtrierpapier zugedeckt und gründlich mit Eis abgekühlt**. Nach Abschluss der Reaktion wird das absorbierte Jod mit $\frac{1}{10}$ N-, oder, noch besser, $\frac{1}{20}$ N-Hyposulfitlösung titriert. In anderen 50 ml spirituswässeriger Lösung wird der Gehalt an freiem Jod ermittelt.

Auf die gleiche Weise—durch Oxydieren mit Eisen-Ammoniumalaun und nachfolgendem Destillieren des freigewordenen Jods—wird der Jodgehalt in der anfänglichen Jodkali-Spirituslösung bestimmt.

Die Peroxydzahl, ausgedrückt in Grammen Jod, welche aus dem Jodwasserstoff mittels der in 100 g der untersuchten Substanz, z. B. Cracking-Benzin, enthaltenen Peroxydverdindugnen ausgeschieden wereden, berechnet sich nach der Formel

hier ist

$$\text{P.-Z.} = \frac{[a - 5(b - c) - e]T \cdot 100}{n \cdot d},$$

a die Menge Hyposulfit in ml, welche für die Titrierung des in den zu Anfang gegebenen 25 ml Spirituslösung von Jodkali enthaltenen freien Jods aufgewandt wurde;
b—die Anzahl ml Hyposulfit, welche fur das Titrieren des destillierten Jods verbraucht wurden;
c—die Anzahl $Na_2S_2O_3$, welche für die Bindung des in 50 ml spirituswässeriger Lösung enthaltenen freien Jods benötigt waren;
e—die Anzahl ml $Na_2S_2O_3$, welche das Jod im Kontrollversuch binden;
T—der Titer des Hyposulfits auf Jod;
n—die Anzahl ml des Produkts;
d—dessen spezifische Gewicht.

Um die Peroxydzahl in den geläufigen Gramm-Aquivalenten von aktivem Sauerstoff auszudrücken, wäre in der angeführten Formel der Titer des hyposulfits nicht auf das Jod, sondern auf den Sauerstoff zu beziehen.

Sämtliches Versuchsmaterial, welches die dargelegte Methode in verschiedenen Einzelheiten begründet, soll in einer demnächst zu erscheinenden Veröffentlichung genauer erörtet werden.

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Eingegangen
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* Das Schütteln darf nicht allzu energisch sein, um der Bildung einer standfesten Emulsion vorzubeugen.

** Während des Destillierens muss die Flüssigkeit im Rezipienten periodisch geschüttelt werden.

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GÉOLOGIE

UNE TERRASSE EUXINIENNE ANCIENNE DANS LES ENVIRONS DE TOUAPSÉ

Par A. EBERZIN et O. VJALOV

(Présenté par A. Archangelskij, de l'Académie, le 29. I. 1936)

L'extrême pénurie des renseignements figurant dans la littérature sur les terrasses marines du rivage caucasien de la mer Noire nous engage à publier quelques données concernant une des terrasses des environs de Touapsé. Les observations géologiques ont été effectuées au cours des recherches géologiques générales, conduites par O. Vjalov en 1930 et 1935, la détermination de la faune et les estimations de l'âge de cette terrasse, basées sur cette détermination, sont faites par A. Eberzin.

La terrasse en question, signalée déjà dans de précédantes publications (²) est très nettement accusée et la plus constante dans la région de Touapsé. En plus d'un ressaut fortement prononcé, qu'on peut poursuivre ici presque partout, on observe en divers endroits aussi des formations de terrasses représentées par des sables et des galets. On peut les voir, par exemple, dans une tranchée pratiquée pour la chaussée près de la station Goloubeva Datcha au sud de Touapsé, près du phare de Kadoche, un peu au nord de Touapsé, en haut du rocher tombant à pic de Kiselev, et encore plus au nord, non loin de l'embouchure du Néboug, dans une tranchée de la chaussée de Novorossiisk (19 km de Touapsé). La hauteur de cette terrasse est de 50—60 m au-dessus du niveau de la mer.

Entre le 15ème et le 16ème kilomètre de la chaussée de Novorossiisk, là où la chaussée s'approche du ressaut littoral, sur les roches primaires du «flysch sombre» apparaissent aussi des galets de terrasses. Au-dessus, on voit en divers lieux des dénudations d'un terrain coquilleux poreux consistant en menus fragments de coquilles. Quelques portions de ce terrain coquilleux, d'une épaisseur apparente atteignant 40 cm, sont cimentées en un calcaire assez compact. Par endroits apparaissent des portions de terrain à coquilles plus grosses.

C'est la faune ici recueillie qui a servi pour déterminer l'âge de cette terrasse. Les échantillons en sont conservés au département de géologie régionale du Musée Géologique Central de Léningrad (collection 3762, échantillons 129—133). Ils représentent des pièces de calcaire coquillier détritique compact, mais poreux, de teinte gris-jaunâtre.

Des fragments de coquilles d'une grosseur considérable se trouvent dans les échantillons 129 et 132. Les échantillons 130, 131 et 133 ne contiennent

que des petits fragments ne pouvant rien donner pour la détermination de l'âge de la terrasse. Il faut remarquer que parmi des fragments de faune, on y trouve de menus galets bien roulés formés de roches sédimentaires foncées, telles que marnes, schistes etc. Ces galets du reste ne se rencontrent pas bien souvent et sont subordonnés à la masse fondamentale des fragments de coquilles consistant presque exclusivement en représentants de la famille des *Cardidae*.

L'examen des fragments nous permet de les déterminer comme appartenant au genre *Didacna* Eichwald et même au groupe *Didacna crassa* Eichw. Outre les fragments de *Didacna*, il y a des restes plus rares de coquilles de *Dreissena polymorpha* Pall. et un exemplaire de *Neritina*.

La liste complète de la faune des échantillons 129 et 132 se présente sous l'aspect suivant:

Didacna gr. *crassa* Eichw. (très fréquente, formant la roche),
Dreissena polymorpha Pall. (pas rare)
Neritina sp. (*liturata* Eichw.?)

Les formes enumérées mettent hors de doute l'appartenance de cette terrasse au type caspien des terrasses de la mer Noire. Les fragments de *Didacna* gr. *crassa* accusent la plus grande ressemblance avec la *Didacna crassa* Eichw. (s. lato) des dépôts euxiniens anciens des presqu'îles de Kertch et de Taman. Cette circonstance nous permet d'adopter pour âge le plus probable de la terrasse de Touapsé l'âge euxinien ancien. Il faut noter que l'attribution de l'âge euxinien ancien à cette terrasse a été suggérée déjà par A. Archangelskij de l'Académie et N. Strachov ([1], p. 28). Les données nouvelles, exposées ci-dessus, confirment entièrement cette hypothèse.

La faune des formations correspondantes sur le rivage caucasien de la mer Noire n'était connue à ce jour que pour la région comprise entre Gelendjik et Djoubga et un peu au sud de Djoubga ([1], p. 27).

Institut des Pétroles.
Léningrad.

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BIOCHIMIE

LA TENEUR EN GLYCOGÈNE DES ASCARIDES

Par I. SMORODINCEV et K. BEBEŠIN

(Présenté par A. Richier, de l'Académie, le 28. III. 1936)

Le glycogène joue un rôle de premier ordre dans la vie des vers parasitaires, représentant une des principales parties constituantes de la masse de leur corps (1). Les différences dans la composition chimique des diverses espèces animales ont une grande importance en biologie comparée; c'est pourquoi nous nous sommes décidés à étudier la composition chimique générale des ascarides et à fixer notre choix sur le glycogène. Nous avons employé la même méthode qui nous a déjà servi pour la détermination du glycogène dans les ténias (1).

Les résultats de nos analyses sont donnés dans la table 1.

Table 1

Teneur en glycogène, en %	Poids cru		
	Minimum	Maximum	Moyenne
Ascaris lumbricoides ♂	2.93	8.42	6.13
6.30 | 8.42 | 5.37 | 6.35 | 3.60 4.40 | 7.00 | 6.68 | 6.83 | 5.28 6.81 | 6.68 | 2.93 | 5.50 | 7.14 6.78 | 6.93 | 6.68 | 6.52 | 6.35			
Ascaris megalocephala ♂ (2)	—	—	2.9
Ascaris lumbricoides ♀	4.85	11.48	8.67
9.28 | 9.10 | 10.23 | 9.36 | 7.21 9.80 | 8.36 | 8.54 | 11.48 | 6.14 4.85 | 5.52 | 10.15 | 10.78 | 9.45 9.31 | 8.30 | 8.24 | 6.00 | 8.50			
Ascaris megalocephala ♀ (2)	—	—	3.8
Ascaris lumbricoides (3)	4.2	7.1	5.71
Ascaris mystax du chien	—	—	4.4

Nos observations ont établi, en conformité avec les données de Toryu [2] concernant l'*Ascaris megalocephala*, que les femelles d'ascarides contiennent en moyenne 40% de plus de glycogène que les mâles.

Table 2

Composition chimique comparée des ténias ronds et plats en pourcentage

Vers	Résidu sec	Substances organiques	Albumine	Glycogène	Lipoides	Cendre
Solitaire du bœuf . .	12.20	11.55	4.0	7.37	1.36	0.65
Solitaire du porc . .	8.71	8.23	4.0	2.17	1.41	0.53
Cestodes larges . . .	9.50	9.04	5.69	1.90	1.54	0.43
Ascarides mâles . . .	19.18	18.39	9.88	6.13	1.23	0.78
Ascarides femelles [4]	19.71	18.93	9.13	8.67	1.50	0.79

La table 2 donne la composition chimique comparée des vers intestinaux ronds et plats.

Nous voyons que les femelles d'*Ascaris lumbricoides* contiennent plus de résidu sec, de glycogène et de graisse, mais moins d'albumine, en comparaison avec les mâles, la composition étant la même pour la partie minérale. La structure des ascarides est bien plus dense que celle des ténias: leur résidu sec représente le double du résidu sec du *Taenia solium* et du *Diphyllobothrium latum*,—principalement aux dépens d'une quantité de glycogène triple ou quadruple et d'une double quantité d'albumine, la teneur en lipoides étant la même, tandis que la quantité de cendre se réduit à peu près à la moitié. Le *Taeniarhynchus saginatus* contient environ la même proportion de glycogène et de lipoides que les ascarides, presque deux fois et demie moins d'albumine et moins de cendre; par conséquent, le résidu solide du *Taeniarhynchus saginatus* occupe une position intermédiaire entre les ascarides et les deux autres espèces de ténias.

En comparaison avec les vertébrés supérieurs les ascarides les plus denses contiennent 10% moins d'eau, 20% moins d'albumine, trois fois moins de cendre et 10 fois moins de lipoides, mais 12 fois plus de glycogène.

On peut attribuer à la haute teneur en albumnie et en glycogène l'activité plus élevée des ascarides, en comparaison avec celle des ténias.

Le présent travail a été effectué avec la participation de E. Koulitchenko

Conclusions

1) De 20 déterminations de glycogène on trouve en moyenne 32% de résidu sec chez les ascarides mâles et 44% chez les femelles.

2) Quoique le pourcentage de glycogène dans les ascarides soit environ le même que dans les *Taeniarhynchus saginatus*, il est bien moindre par rapport au résidu sec.

2) L'*Ascaris lumbricoides* contient 2—3 fois plus de glycogène que le *Taenia solium* et le *Diphylobothrium latum*.

4) La teneur en glycogène des ascarides mâles surpasse cinq fois leur teneur en lipoides.

5) Les ascarides mâles contiennent une fois et demie moins de glycogène que d'albumines.

6) Les ascarides femelles contiennent environ six fois plus de glycogène que de lipoides et fort peu moins que d'albumines.

7) En conformité avec leur teneur bien plus considérable en albumines les ascarides sont beaucoup plus actives que les ténias.

8) Les ascarides ne diffèrent pas des ténias par leur teneur en lipoides.

9) Les ascarides contiennent une fois et demie plus de cendre que les ténias.

10) Les ascarides contiennent 12 fois plus de glycogène que les vertébrés supérieurs.

11) En comparaison avec les vertébrés les ascarides contiennent 10 fois moins de lipoides, trois fois moins de cendre, 10% moins d'eau et 20% moins d'albumines.

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GENETICS

HYBRIDS BETWEEN THE JERUSALEM ARTICHOKE *(Helianthus tuberosus* L.*)* and the SUNFLOWER *(Helianthus annuus* L.*)*

By N. A. ŠČIBRIA

(Communicated by N. I. Vavilov, Member of the Academy, 21. III. 1936)

Interspecific crosses within the genus *Helianthus* L. have been made by various investigators. The most interesting of these crosses are those between the more distant species, as, for instance, between annual and perennial species.

As Wagner (5) has pointed out, these crosses have in some cases been made without sufficient care, and, consequently, in these cases the results obtained have been doubtful. Moreover, in the majority of these crosses the species selected were of little practical interest, and so no forms of practical value were obtained.

The Maikop Experiment Station of the Institute of Plant Industry at Shuntuk in the Azov-Black Sea Region (North Caucasus) has been conducting hybridization experiments between *Helianhus* species selected primarily for their practical value. On the one hand, there was taken the annual cultivated sunflower, *Helianthus annuus* L., and, on the other, the perennial, tuber-bearing species, *H. tuberosus* L. and *H. macrophyllus* Willd. H. *annuus* L. has 34 as its diploid chromosome number [Tahara, 1915; Prozina (4), 1924; Makovetsky (3), 1929]. In *H. tuberosus* L. $2n=102$ [Makovetsky (3), 1929]; $n=51$[Wagner (5), 1932; Kostoff (2), 1934]. The haploid chromosome number of *H. macrophyllus* Willd. is also 51 [Wagner (5), 1932].

The hybrids *H. tuberosus* L. × *H. annuus* L. were first obtained by the writer in 1935. Two varieties of Jerusalem artichoke—Blanc amélioré (Vilmorin) and Krasny Maslovsky (local Ukrainian variety)—were taken as the mother plant. A special form of sunflower from India—selected from the collections of the Institute of Plant Industry (Catalog No 740, Section of Oleiferous Crops) — was used as the paternal plant. This form belongs to the group of ornamental sunflowers, and is distinguished by the fact that some of its segregates are plants with pure female flowers.

From these seeds there were grown in 1935 a total of 15 plants from the combination Blanc amélioré × sunflower and 3 plants from the combination Krasny Maslovsky × sunflower. Three plants from the first combination and one from second had the usual appearance of artichoke seedlings obtained by open pollination. The rest of the plants (12 from the first combination and

2 from the second) were markedly different in habit, undoubtedly being hybrids between the Jerusalem artichoke and the sunflower. In addition, among the Krasny Maslovsky seedling obtained from open pollination there was one plant which by its general habit showed itself to be a natural hybrid between the Jerusalem artichoke and the sunflower. Thus, there were obtained a total of 15 artichoke-sunflower hybrids.

Without giving a detailed desription of the characters and behaviour of the F_1 hybrids and the parental forms, it may be said that, as regards most characters, the hybrids even from the same cross differed considerably from one another. With respect to the overwhelming majority of the characters of the parental forms, the F_1 hybrids proved to be intermediate. Among such characters were: height and thickness of stalk, density and character of pubescence and anthocyanin pigmentation of stalk; density and character of branching; number, size, and shape of leaves, number and size of inflorescences; number of disk and ray flowers; length of vegetation period (time of flowering). As regards each of these characters there was observed in the hybrids a considerable range of variation as between the maternal and paternal types, tending, however, to approximate the former more closely than the latter.

With respect to immunity from leaf rust (*Puccinia Helianthi* Schrad., his character of the Jerusalem artichoke proved completely dominant, all the hybrids being free from rust. In the case of the cross Blanc amélioré × sunflower tuber-formation also proved to be dominant, but in the case of the Krasny Maslovsky × sunflower cross one of the two hybrid plants did not form any tubers. Not a single character showed complete dominance of the paternal type.

In Table 1 are given comparative data as to the hybrids from the cross Blanc amélioré × sunflower and the parental forms with respect to several quantitative characters.

Table 1

Plants \ Characters		Height of stalk (in cm)	Number of leaves on main stalk	Density of foliage (ratio of height to number of leaves)	Ratio of width to length of leaf blade (in %)
Hybrids between Blanc amélioré artichoke and a stamenless sunflower	No 1	286	79	3.62	79
	2	255	105	2.43	79
	4	260	93	2.80	87
	6	228	95	2.40	78
	7	205	77	2.66	66
	8	272	109	2.50	72
	10	240	125	*1.92*	72
	11	205	77	2.66	76
	12	242	101	2.40	79
Blanc amélioré artichoke	from tubers	319	130	*2.45*	73
	» seeds	166	—	—	—
Stamenless sunflower		167	28	*6.0*	95

As regards certain characters some of the hybrid plants exhibited heterosis, they went beyond the limits set by the parental forms. Thus, plants Nos 6 and 12 (see Table 1) slightly and plant No 10 very considerably surpass in density of foliage the Jerusalem artichoke, which has much denser foliage than the sunflower. With respect to height of stalke, the hybrids exceed the sun-

flower but do not come up to the Jerusalem artichoke grown from tubers. However, as compared with artichoke seedlings, which is a more correct comparison, all the hybrids exhibited heterosis as regards this character as well. The same holds true for density of branching, almost all the hybrids exhibiting very luxuriant growth of their tops.

The character of the tubers and the tuber cluster in the tuber-bearing hybrids is entirely different from that in the Jerusalem artichoke. In the latter the tubers are pyriform or more or less globular in shape, while the tubers of the hybrids are fleshy in consistency and for the most part of a more elongated shape.

The natural hybrid between the Krasny Maslovsky artichoke and the sunflower is of great interest. In this instance the paternal plant apparently was a different form of sunflower, more vigorous in development (most probably an oleiferous sunflower from a cultivated field), in consequence of which the n a t u r a l h y b r i d was distinguished by its very large size, attaining a height of over three metres at maturity. As regards thickness of stalk and shape and size of leaves, the hybrid resembled an ordinary sunflower, for which it might be taken at first glance. However, the shape of the leaf base, the character of pubescence and branching, and a number of other characters of the tops, not to mention the tubers, revealed its hybrid origin.

All the hybrids flowered profusely, and a few proved to be fertile, producting a small quantity of seed under conditions of open pollination.

In Table 2 are given data regarding the quantity of tubers and seeds produced by the hybrids:

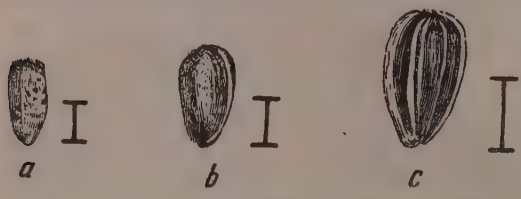
Table 2

Hybrid combination	Plant No	Number of tubers	Weight of tubers (in kg)	Number of seeds	Remarks
Blanc amélioré artichoke × stamenless sunflower	1	69	4.50	0	
	2	84	3.65	0	
	3				Broken down by storm
	4	44	2.05	0	
	5				Broken down by storm
	6	33	3.15	2	
	7	84	2.00	0	
	8	33	1.90	0	
	9	18	1.25	0	Damaged by storm
	10	27	1.85	1	
	11	99	2.05	18	
	12	37	1.85	1	
Krasny Maslovsky artichoke × stamenless sunflower	1	14	0.90	0	
	2	0	0	0	
Natural hybrid Krasny Maslovsky artichoke × sunflower	1	33	1.15	3	Damaged by storm

The seeds of some of the hybrids, as regards shape, colour, and size, were intermediate between the parental forms (Fig.).

A cytological investigation of the somatic cells of the hybrids, made by P. M. Mamulashvili, showed that their diploid chromosome number was appoximately 68.

The work initiated on interspecific hybridization within the genus *Helianthus* L. is of great theoretical and practical significance. First, the possibility of obtaining hybrids between such distant species as *H. tuberosus* L. and *H. annuus* L., as well as their occurrence sometimes by natural means without human participation, confirms the opinion of Cockerell (1) and Kostoff (2) as to the role of hybridization in the process of form-genesis within the genus *Helianthus* L. and leads to recognition of the need of revision of the taxonomy of this genus. Secondly, the possibility of freely combining different species characters in new forms, stabilized by means of vegetative propagation, considerably extends the perspectives of breeding within the genus *Helianthus*, giving a basis for the creation of new forms of practical value combining qualities of different species of *Helianthus*, such as a perennial, tuber-bearing sunflower not affected by rust (*Puccinia Helianthi* Schrad.), broom-rape or strangle-weed (*Orobanche cumana* Wall.), etc. In addition, by interspecific hybridization within the genus *Helianthus* L., it is possible to make use of heterosis and of the new forms arising from hybridization having practical value (*e. g.*, compact clusters of tubers, formation of tubers at a more shallow depth).



Seeds: a) of «Krasny Maslovsky» artichoke; b) of the natural hybrid «Krasny Maslovsky» artichoke × sunflower; c) of an oleiferous sunflower.

Lastly, some of the Jerusalem artichoke × sunflower hybrids already obtained, due to their luxuriant growth and dense branching and foliage, constitute forms of practical value as perennial silage plants for northern districts of the USSR.

The present work was carried out under the personal guidance and supervision of Academician N. I. Vavilov, to whom the writer wishes to express his deep gratitude.

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GENETICS

STRUCTURAL CHANGES IN CHROMOSOMES INDUCED BY IRRADIATION OF PHYSIOLOGICALLY MODIFIED CELLS

By M. A. SIZOVA

(Communicated by N. I. Vavilov, Member of the Academy, 16. III. 1936)

The method of obtaining structural changes in chromosomes most commonly employed is that of the application of X-rays. The purpose of our investigations was to study the effectiveness of X-ray treatment in producing such changes in chromosomes previously subjected to the action of certain physical and chemical agencies. These agencies—carbon dioxide (CO_2), ammonia (NH_3), and low temperature—were selected as corresponding most closely to possible natural conditions.

The carbon dioxide was obtained in a Kipp generator as the result of the action of hydrochloric acid on marble. Before filling the exsiccator, in which the seedlings to be experimented upon had been placed, with this gas, the latter was passed for cleaning through two flasks filled with water. In order to detect the possible presence of hydrochloric acid vapours in the carbon dioxide, a solution of silver nitrate ($AgNO_3$) was added to the water in the flasks. The failure of the silver nitrate to show any reaction to hydrochloric acid indicated the absence of the latter.

The plant used in these experiments was *Crepis capillaris*.

Preliminary investigations as to the effect of the medium on the chromosome apparatus showed that cell division ceases in seedlings placed for a period of six hours in an exsiccator filled with carbon dioxide. In root tips, however, fixed after having remained in this gas for five hours, cell division continues. No structural changes in the chromosomes were revealed. All of the thirty plates examined by us proved to be normal. Investigation of the root tips of seedlings, which after having remained in the gas for five hours were subjected to X-ray treatment, showed that the percentage of plates revealing structural changes in the chromosomes was considerably higher than in the case of control seedlings subjected to X-ray treatment only. In the latter case, out of 104 plates, only 27, or 26 per cent, revealed structural changes, while the other 77 plates were normal. In the former case, *i. e.*, when both carbon dioxide and X-rays were used, out of 145 plates examined, 73, or 50 per cent, revealed structural changes and only 72 were normal. The considerable increase in the percentage of plates revealing changes is due, presumably, to the effect of the medium—in this instance carbon dioxide —in which the seedlings were kept prior to the X-ray treatment.

The structural changes in chromosomes resulting from combined treatment with carbon dioxide and X-rays do not differ essentially in character from those produced by X-ray treatment alone. The usual types of changes resulting from X-ray treatment were found to be translocation, association, trisomics, fragmentation. The last-mentioned type, though it did not predominate in our experiment (out of the 73 plates revealing changes, only 14 showed fragments), was subjected to a particularly thorough investigation to establish its authenticity.

A study was also made of the effect of NH_3 on the seedlings. They were placed in an exsiccator having a capacity of 925 cm^3 and containing 100 cm^3 of a 0.01 per cent solution of NH_3 generated from ammonia of a strength of 15.9 per cent. After remaining in this medium for seven hours, multiplication of cells in the root tips ceases and decay sets in. In root tips, fixed after remaining six hours in NH_3 vapours, it was found that some of the cells, despite the fact that decay had already set in, were undergoing division. Investigation of this material showed that in this case also there were no structural changes in the chromosomes. The 44 plates examined were all normal, but there was a clearly perceptible thickening of the chromosomes. In seedlings first subjected to the action of NH_3 for a period of six hours and then to X-ray treatment there was revealed, just as in the experiment with CO_2 and X-rays, considerable increase in the percentage of plants showing changes, as compared with seedlings subjected only to X-ray treatment. Thus, in the latter case, only 26 per cent of the plates showed changes, while with the combined NH_3 and X-ray treatment, there were 44 per cent of such plates—60 out of a total of 135 plates examined, the remaining 75 being normal.

From the above data it is clear that, by combining the action of X-rays with that of certain media, a considerably greater number of structural changes in the chromosomes occur. The gases CO_2 and NH_3 by themselves do not, on the other hand, produce any structural changes.

In order to verify the results of these experiments, the numerical data obtained on the effect of combined treatment with X-rays and one of the two gases and of treatment with X-rays alone (as control) were subjected to statistical analysis, which fully confirmed our results. In the first experiment $D/m=4$; in the second $D/m=3.1$.

Let us now consider the combined effect of X-rays and low temperature. Preliminary investigation of root tips of seedlings subjected to low temperature revealed a shortening of the chromosomes, the usual effect of this kind of agent. Combining the two treatments, the seedlings were first placed in ice for 24 hours and then X-rayed. The results of cytological examinations made after such combined treatment were as follows: out of 98 plates examined, 59 were normal and 39, or 40 per cent, showed changes. The control experiment, *i. e.*, treatment with X-rays only, showed that out of 74 plates examined, 51 were normal and 23, or 31 per cent, showed changes. In this case we see that the difference between the percentage of plates showing structural changes as a result of combined treatment and the percentage of such plates resulting from X-ray treatment alone is not great —only 9 per cent. Statistical analysis of the data obtained from this experiment did not fully confirm this difference ($D/m=1.3$).

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PLANT PHYSIOLOGY

REACTION OF THE DRUMHEAD CABBAGE TO LOWERING OF TEMPERATURE

By L. V. MICHAJLOVA

(Communicated by A. A. Richter, Member of the Academy, 8. III. 1936)

Academician T. D. Lysenko's theory of development by stages, and the method of yarovization (vernalization) based on it have found a wide application and confirmation in agricultural practice and have at the same time opened new formes of controlling not only the development but also the growth processes of plants. The latter is manifested especially clearly in cases when the stage of yarovization is not completed or when the vegetation is retarded in transition to the next stage.

Thus, for example, the yarovization of flax seed gives a lengthened fibre.

According to S. M. Ivanov (1), the refrigiration of the poppy, coriander, sunflower, safflower and the mushroom (*Lactarius delicosus*) at the beginning of growth greatly increased the yield and the strength of the plants and at the same time retarded the flowering.

An opposite reaction was observed in the chick-pea and lentil.

In our experiment of the yarovization of the seed of drumhead cabbage at temperatures of +2 to +6° C during the course of 30, 68, 98 and 130 days, an increased yield resulted independently of the duration of yarovization; that is, an increas in the weight of the head of the vernalized plants as a result of intensified vegetative growth.

In the case of the variety Number One, this increase varied during the two years from 10.5 to 30%, while in the case of the Slava variety it equaled to 33.8%.

It should be stated that all that is said in this paper about the influence of lowered temperatures on cabbage heads is based on the data from early ripening varieties: Number One and Slava. The late varieties, Late Moscow and Amager, did not manifest a reaction within the limits of our experiments—neither on refrigeration of the seed nor on refrigeration of the seedlings.

However, intensification of vegetative growth after yarovization of the seed is connected with conditions of the plant's further growth.

For example, when seedlings of drumhead cabbage were refrigerated at temperatures of from + 2 to +10° at the age of to 2 months for 60 days, a reverse effect resulted, namely, a decreased weight of the head of the plants so refrigerated in comparison with the controls.

In the table are represented the results obtained from 3 variants of vernalization of the «Number One» variety: 1) yarovization of the seed; 2)

yarovization of month-old seedlings; 3) double yarovization—that is, of the seed and of the seedlings.

The data include the weight of the head both in absolute and in relative figures and the percentage of plants, that produced scapes.

The latter, however, did not flower and appeared only as stalked plants with abundant heads.

Variant	Weight of Head		Percentage of plants that produced scapes
	Grams	Relative figures	
Control (unyarovized)	1 375	100	0
Yarovized seeds	1 520	110.5	0
Yarovized month-old seedlings	1 110	77.0	12.5
Double yarovization (of both seeds and seedlings)	1 307	95	6.3

From this table it is evident that though the average weight of head from yarovized seed is higher than the control by 10.5%, refrigeration of the seedlings alone lowered the weight of head in comparison with the control by 23%. In the case of double yarovization—of both seed and seedlings—the weight of the head occupies an intermediate position.

The percentage of plants that produced scapes from vernalized seedlings is twice as great as from double yarovization, and was zero from yarovized seed. Thus on the basis of the data of the table it is possible to draw the following c onclusions:

1. Yarovization of cabbage seed (for 30 to 130 days) at a temperature of +2 to +6° intensifies the growth processes, increses the size of the giant buds but gives no scapes at all.

2. Yarovization of the same variety of cabbage as a month-old seedlings at a temperature of +2 to +10° retards the growth processes, lessens the size of the head and facilitates the formation of scapes under the same conditions of subsequent growth as those in the first variant.

3. In the case of double yarovization (of both seed and seedlings) the plants take an intermediate position in weight of head and in percentage of plants, that produced scapes between the two foregoing variants.

The reason for the intensification of vegetative growth as a result of yarovization of the seed is apparently as yet a puzzle and requires further investigation.

Thus, a double and mutually opposite action of lowered temperatures on the germinating seed and on the seedlings of cabbage has been noted.

In the first case (action on the seed) lowered temperatures intensify the growth processes and retard the development of the plant.

In the second case (action on the seedlings) development is hastened, but the growth processes are retarded. Apparently the stage of yarovization of cabbage (action on the seed) should lie within the limits of other complex of factors, factors that were absent in our experiments.

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PLANT PHYSIOLOGY

LIGHT REGIME REQUIREMENTS OF TOMATOES

By L. V. MICHAJLOVA

(Communicated by A. A. Richter, Member of the Academy, 8. III. 1936)

The tomato's land of origin is tropical America—a land having a short day.

It would, therefore, seem natural to include the tomato among short-day plants as regards their photoperiodic reaction. However, we find contradictory or unconvincing data iu the literature with respect to this question.

J. Adams ([1],[2]), M. E. Deats ([3]), J. M. Arthur and others ([4]), and G. T. Nightingale ([5]) refer the tomato to long-day plants although the data of some of the authors are equivocal. For example, Arthur and other observing the flowering of tomatoes in 7-, 12-, 17-, and 19-hour days, found the greatest weight of plants to occur in 1934 in the 17-hour day, while in 1925 it occurred in the 12-hour day. In the experiments of Nightingale ([5]), tomatoes treated to three weeks of a 14-hour day, but deprived of nitrogen, had a sickly appearance and bore no fruit, while with the same deprivation of nitrogen, but with a 6-hour day, they had a moderate vegetative development, a dark green colour of the leaves and numerous flowerbuds. Under conditions of the same day length and a supply of nitrogen the reverse reaction was obtained.

Prof. V. I. Edelstein ([6]) refers the tomato to short-day plants.

Practical agricultural experience gives no indication on this question, notwithstanding the fact that tomatoes are grown in the North in hotbeds, in which it would be quite easy to regulate the length of day.

Desiring to utilize these conditions of tomato growing in the North for a study of their light requirement and its influence on their growth, we conducted a series of experiments with photoperiodic afteraction.

On the basis of the data regarding the tomato's origin, one might expect that it would react positively to the short day. Consequently, our plan involved three variants: a 9-hour day, a 12-hour day and the long natural spring day of the middle belt, which inreased from appoximately 14 hours 30 minutes at the time of transplanting the seedlings on April 20 to about 17 hours 30 minutes on June 10. The third variant served as a control.

From the moment the seed sprouted until the seedlings were set on the field, the daylight period was regulated by means of covering the hotbeds with flat two-ply straw shields.

The hotbeds were shaded mornings and evenings. The control plants were covered only during the cold night hours with single-ply shields.

The temperature was kept the same in all hotbeds.

The seedlings were left growing in the hotbeds from April 12 till May 27 in 1934, and from May 12 to June 22 in 1935.

Before being transplanted, the plants with the exception of the «Humbert» variety, were forming flowerbuds, but had not yet flowered.

After transplantation, we continued our observations on the plants and calculated the yield. In order to investigate the question of the influence of the short day on tomatoes in other period of development also, a part of the 12-hour day plants continued to be shaded in the field, these plants, consequently, had a 12-hour day during their whole vegetative period. A part of the control plants, also, were shaded (they received a 12-hour day) after being set out in the field; these plants, then, received the short day only after flowerbud formation. Experiments were carried out with the following varieties: Best of All (2 years), Pierretta (2 years), Sparks Gribovski (1 year) and Humbert (1 year). The additional experiments in the field were carried out only with two varieties: Best of All and Pierretta.

Observations on the rate of the plants' development showed that subjection to the short day before flowerbud formation, hastens the development, although not so markedly as has been noted in the case of the soy and millet, for example.

Thus, by Pierretta variety the flowering of 50% of the 9-hour afteraction variant occurred 15 days earlier than that of the control; flowering of the 12-hour variant occurred 9 days earlier. Ripening began 8 days earlier in the case of the first variant and 13 days earlier in the case of the second. In the case of the Best of All variety, the corresponding dates were only 2 to 5 days earlier.

The hastened development of the plants due to short-day treatment was especially obvious from the number of ripe fruits at picking time. It was higher by from 2 to 147%, depending on the variety and day length, in the case of plants that were shaded in the hotbeds, than in the case of the controls.

The shortened day before flowerbud formation manifested a favourable action on the growth processes also. The plants of the 12-hour afteraction occupied first place in the strength of growth of the seedlings at the time they were transplanted in the field.

In the matter of yield, both short-day variants of the various varieties and in the various years contend for first place, whereas the control everywhere occupied the last place.

The table gives a picture of the size of the yield and of the development of the controls and the plants experimented on. In all experiments the short-day variants proved superior to the controls both in yield and in percentage of ripe fruit at picking time. Only the Best of All variety that was subjected to the 12-hour afteraction in the field plot fell in number of fruit to 92.3%, but the weight of the fruit was still 9.6% higher than the control, while the percentage of ripe fruits was 52% higher than in the case of the control. On the zame plot the weight of the lruits of plantz zubjected to the 9 hour afteraction was greater by 37%, the number of fruit was greater by 12.2% and the percentage of ripe fruits was greater by 8%.

The data presented in this table indicate that the weight of the fruits and the percentage of ripe fruits were for all varieties higher as a result of photoperiodical afteraction, than was the case with the control.

The Pierretta variety reacted best to the 12-hour day given before flowerbud formation, although the percentage of ripe fruits was higher for the 9-hour day variant. Best of All, Sparks Gribovski and Humbert reacted

Variety and Variant	Weight of fruits of one plant		% of ripe fruits	Number of days till ripening	% of plants not giving ripe fruits
	Percentage	Grams			
Pierretta					
Control	100	681*	100	131.5	0
12-hour day until flowerbud formation	126.1	859	101.8	118.2	0
9-hour day until flowerbud formation	124.0	845	144.1	123.3	0
12-hour day after flowerbud formation	134.2	914	85.9	129.0	15
12-hour day during whole vegetative period	122.3	833	45.5	131.0	5
Best of All					
Control	100	572	100	154.7	2.6
12-hour day until flowerbud formation	116	629	109	150.7	2.5
9-hour day until flowerbud formation	126	698	113	148.5	0
12-hour day after flowerbud formation	112.8	732	85.5	156.4	10
12-hour day during whole vegetative period	100.9	577	82.5	156.6	2.6
Starks Gribovski					
Control	100	944	100	—	—
12-hour day until flowerbud formation	105.3	944	102.5	—	—
9-hour day until flowerbud formation	126.6	119.5	114.4	—	—
Humbert					
Control	100	265	100	—	—
12-hour day in hotbeds	197	522	180	—	—
9-hour day in hotbeds	212	582	247	—	—

* The weight of fruits of one plant was in 1935 300—400 grams on an average, that is lower than usual due to unfavourable meteorological conditions of this year.

best to the 9-hour day both in respect to increase of yield and percentage of ripe fruits. But in 1934, the Best of All variety made a better showing with the variant of the 12-hour afteraction.

The increase of yield as a result of the action of the short day reached, as is seen from the table, 112% in the case of the Humbert variety, while the percentage of ripe fruits was 147% in comparison with the control.

Thus, tomatoes react positively to the short day at the beginning of their development and, the more southern the variety in the matter of origin, the stronger the reaction.

They react otherwise to the short day given after flowerbud formation as is to be seen from the data of the two supplementary variants in the field.

In 1933 the yield of the Pierretta variety dropped 41% in comparison with the control, as a result of the 12-hour action throughout the course of the whole vegetative period. In 1934, the Best of All variety, subjected to the same treatment, fell off 11% in yield; whereas plants shaded only after flowerbud formation decreased the yield by 17%.

In 1935 the negative action of shading after flowerbud formation was expressed in a delayed ripening of the fruits. It is evident from the table that the percentages of ripe fruits of plants shaded after transplanting in the field and those shaded for the whole period are lower than the control by 14.5 to 17.5% in the case of the Best of All variety, and by 14 to 54.5% in the case of the Pierretta. The higher yield of these varieties in 1935 is to be explained by the better meteorological conditions in which the plants shaded in the field were placed. That is to say, they had minimum night temperatures that averaged 1.5 to 3° higher than in the open plots (shading was effected by means of portable boxes).

Besides this, they were protected from the drenchings to which the open plots were subjected during the night, morning and evening hours.

On the basis of the data set forth above, the following conclusions may be drawn:

1. Tomatoes react positively when subjected to the short day from the beginning of their development up to the stage of flowerbud formation and negatively to a shortening of the day to 12 hours after flowerbud formation. The reaction manifests itself in acceleration or retardation of development and in increased or diminisched yield.

2. Subjection to the long day (the summer day of the middle belt of the RSFSR) after flowerbud formation hastens the development of the plants and increases the yield in case they were subjected to a short day previously. It is by this difference in the requirements of tomatoes at different periods of their life cycle that we explain the ambiguity in the work of foreign authors, since it prevented their establishing the photoperiodic reaction of the plant. Most of these authors began to shorten the day at a comparatively late period of the life cycle and this led them to refer tomatoes to the plants of the long day.

The correctness of Academician T. D. Lysenko's estimate of the possibility of classifying plants according to their photoperiodic reactions is confirmed fully in tomato culture. On the basis of such a classification tomatoes, before flowerbud formation, must be referred to short-day plant and, after flowerbud formation, to long-day ones.

Our experiments were conducted under the conditions of soil preparation and of temperature that are ordinary in agriculture. We recognize the fact that both these factors play no less a role in the life of tomatoes than the conditions of illumination. On this point there is both literary and practical evidence. For example, in our experiment on the vernalization of tomatoes (which requires verification), the latter reacted to temperatures of 3 and 15° (Best of All variety) no less than to the short day.

Thus, after we have found out the proper vernalization stage and light regime of tomatoes and have given this widely used plant its optimum conditions of nutrition, it will be possible, not only to hasten its fruiting in the middle belt, but also to move some varieties of this extremly valuable vegetable further north, keeping in mind its positive reaction to the long day flowerbud formation.

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EXPERIMENTAL ZOOLOGY

ON THE PECULIARITIES AND CAUSES OF THE DEVELOPMENT OF ADDITIONAL FORMATIONS IN AMPHIBIA

By N. V. NASSONOV, Member of the Academy

Duplicate and multiple formations on the bodies of animals have attracted the attention of numerous scientists, but until now they have been only very slightly investigated experimentally. These formations can be due to different causes. In the majority of cases they are due to wounds.

Of special interest are those duplicate and multiple formations which appear afte the infliction of wounds* not as substitute for lost organs, but as duplicates of existing organs or their parts not destroyed by the wound.

I term such formations reiterated (duplicate) or additional ([1–3,5]). They can occur as the result of internal wounds ([4, 5, 6]) or external ones ([7, 8]). I succeeded in producing such formations in axolotls by subcutaneous insertions of pieces of their cartilage or of a frog one ([3]).

It was shown in all these cases, where the development of additional formations was studied, that the histogenetic processes occur in the same manner as in the development of a reparative regenerate ([6, 3]).

Additional formations may be much smaller in size than the organs or their parts which they duplicate, and often they remain underdeveloped, same as subregenerates. The following two points deserve special mention, firstly that the sagittal planes of additional formations studied were not always coincident with those of the organs or parts duplicated, and secondly that, in all the cases which I had the opportunity of studiying, additional leg parts did not respond to pricking, always remained immobile, and in very underdeveloped specimens the muscles were sometimes absent. I have never observed in sections of such fully developed formations or at different stages of their development that the nerves should grow into them and be directed towards the muscles, as is to be observed in regenerates.

The highest degree of development that any additional formation may attain depends on the site where it appears; thus, the development of additional leg parts does not proceed further than the limit which would be attained by the regenerate if it were to develop on the site of the additional formation after the amputation of the corresponding part of the leg. In other words, in amphibians, in all the cases described, additional formations of leg part duplicate, to

* This group of duplicate or multiple formations does not include formations obtained by certain transplantations of organs and their rudiments; ([15, 16] and others).

a certain degree, only that part of the leg which is distal with respect to the wound and never contain any elements of those parts which are proximal with respect to the wound.

The data in literature on the problem of additional formation in amphibia are very scanty. Della Valle ([4]) obtained an additional formation in a newt on each side of a ligature which had been placed on the place of fracture of the skeleton of the leg, so that the knitting of the bone was impossible. Tornier ([7]) produced additional formations in the same animal on fracturing its femur or in inflicting a wound on the latter. Unfortunately, his description is very short. He writes: «Im ersten Falle bricht man den Oberschenkelknochen der Thiere in der Nähe des Huftgelenkes, indem man zugleich die Weichteile durchschneidet, die über der Bruchtstelle liegen... Dasselbe Regenerationsresultat erreicht man, wenn man in den Oberschenkel, in der Nähe des Huftgelenks eine Kerbe so einschneidet, dass der Oberschenkel dadurch stark verletztz wird». It must be assumed that the cartilages of the skeleton were considerably damaged in the latter case. Puppe ([8]) obtained additional formations on making a transverse incision of leg of a tadpole of *Rana temporaria* in an early stage of its development.

Mention should be also made of the peculiar additional formations which were obtained in *Urodela* by diverting an cut femoral nerve to different places of the body near the base of the leg. Locatelli ([13,14]) obtained such additional extremities on the back mainly by diverting the above-mentioned nerve through the muscles of the back to the surface of the skin, where its end was fixed. During these operations the tissues were wounded, and in some cases, parts of the skeleton were destroyed. Unfortunately, the histogenic processes occurring during the development of these extremities, as also in other cases described by the authors, have not been studied. On inflicting the wound, products of decomposition of tissues were produced, which probably stimulated the formation of chondrioblasts, myoblasts and other elements of which the mesodermic part of the rudiment of the additional extremity is built up. The role of the nerve end also remains obscure.

In all the cases when additional legs were obtained by means of ligatures and fractures of the skeleton, their tips were simultaneously amputated, a regenerate being caused to develop on the wound.

I succeeded in producing additional formations after ligature of the thighs of axolotls without fracturing the bones and without amputating the tips of the limb ([5]).

I usually obtained one additional formation on the proximal side of the ligature or two on both sides. Moreover, sometimes I observed two additional formations to originate on the proximal side of the ligature from one and the same place, as is sometimes the case in supperregeneration after the amputation of a part of extremity.

In all the above-described cases of experimental production of additional formations, injury of the skeleton was a *sine qua non* of their development. Unfortunately in all cases except the last ([6]) no sufficient data were available on the degree of destruction of the cartilage and on the period of time it remained in a destroyed condition. We know that, if duplicate extremities develop on applying ligatures, the destruction of the cutis, skeleton and muscles is complete, and the cartilage does not regenerate all the time the leg is constricted by the ligature ([6]). But, if the ligature slackens during the development of the additional part of the limb or is taken off, the wound heals and the cartilage regenerates. At the same time, further development of the additional formation ceases, and the latter thus remains incompletely develop-

ed, as is the case in subregeneration after amputation of a part of the limb. Most probably one of the causes of the development of additional formations is the presence of destroyed part of the skeleton which containes cartilage.

This is confirmed by my investigations of the phenomena observed on inserting under the skin of axolotls of small pieces of their cartilage ([3]). In this case, if the cartilage decomposes, it may stimulate regenerative processes resulting in the formation of additional parts of the limbs without any parts of the legs being amputated, as is the case in reparative regeneration, and without a weakening of their functions, as is the case when ligatures are applied, *i. e.* without all those phenomena which have been considered to be necessary for the development of regenerative processes.

Since on the subcutaneous insertion of cartilage regenerative processes will develop only if the cartilage decomposes, it is to be assumed that they are caused by the products of its decomposition*. The regeneration of a part of the leg or tail of Urodela, as well as of fins of fisches [Kazancev ([17,18])], after amputation is always accompanied by the destruction of the cartilage adjoining the blastema, and such a destruction may penetrate to a great depth. It is to be assumed that here also cartilage plays an important role stimulating the development of regenerative processes by its products of decomposition. It is very probable that the development of these processes may be due not only to the products of decomposition of cartilage, but also to those of other tissues. I have spoken of the important role of the decomposition products of tissues in the development of regenerates both at the Zoological Congress in 1927 ([1]) and later in 1930 and 1934 ([5,12]).

Since the products of the decomposition of tissues play an important part in the development of regenerative processes in the vertebrates, it is probable that the same holds good for certain invertebrates; but in investigations of regenerative processes occurring in them no attention whatsoever has been paid to elucidating the role of the products of the decomposition of tissues in the development of these processes.

As has already been described above, the legs of newts, which had external wounds inflected or parts of their skeleton fractured, were in all cases amputated at different places distally from the site of the wound, and after that was the formation of a regenerate stimulated. I have carried out experiments with axolotls the leg skeletons of which were fractured without amputating the parts distal with regard to the point of fracture. Seventy fractures were made in regions of the femur or humerus, the skin over the place of fracture either being broken or having an incision made in it so that regenerative processes should not be impeded by the skin, which as is known, inhibits the development of regenerates. I have never observed regenerative processes to occur under such conditions. But if the skeleton is not allowed to unite, additional parts of legs may appear. To have them formed, I used twice a day to bend the legs several times at the place of fracture. The possibility is not excluded that some parts of the legs were injured, but the main blood vessels and nerves remaines intact and the legs responded to pricking in their distal part.

* I am now inclined to think that the cartilage inserted under the skin plays the part of an organizer, as is to be observed in embryonal development. It seems to contain a number of organizing substances among the products of its decompositions, which form when it is under the skin. Such organizing substances represent, not only in cartilage, but also in some other tissues of the axolotls. We shall deal with this in one of our future papers.

12 axolotls had their legs repeatedly bent at the point of fracture during two weaks, so that the several parts of the skeleton did not unite, but after that period they united. In a few days after the cessation of bending, two axolotls showed indisputable regenerative phenomena manifested in the development of duplicate leg parts. In one case, there even developed at the top of the shoulder, anteriorly of the fracture, several additional formations, as is sometimes observed in superregeneration after amputation (Fig. 1 and 2).

Fig. 1. Right anetrior leg of an axolotl with three additional formations (*a*, *b* and *c*) at the top of the shoulder.

Fig. 2. X-ray photograph of the same leg. *a*—additional limb with four digits; *b* and *c*—two additional limbs with three and two digits.

One of these formations was more developed (*a*) and contained certain elements of the meso- and autopodium with well developed digital phalanges joined by a membrane. The two other additional formations were less developed, one of them (*b*) having three fingers joined by a membrane, the other (*c*), very underdeveloped one, having two fingers*.

The development of additional formations after fractures with amputations of the tips of the legs may be probably explained by the regenerations at the tip of the leg hastening the regenerative processes at the point of farcture and these processes resulting in the development of the additional formation. Such formations can develop only while the wound has not healed and the fractured parts of the skeleton have not united. In axolotls this occurs soon enough and thus the products of the decomposition of tissues quickly disappear. A hastening of the onset of regenerative processes might thus promote the development of additional formations. That the development of additional legs can be hastened by that of a regenerate at the tip of leg has been demonstrated by me in experiments of placing ligatures on the thighs and shoulders of axolotls with a simultaneous amputation of the tip of the leg ([5]). The development of duplicate leg parts was by this means hastened as compared with their development when the tip of the leg had not been amputated. We also know that in many animals a hastening of regenerative processes with an increase in the number of similar regenerates ([9],[10],[11]) and others. Since there is no essential difference between additional extremities and reparative regenerates, it should be expected that the formation of additional leg parts is likewise hastened by the formation of a regenerate at the tip of the leg.

* In one experiment with fractures of the skeleton of the extremities, the distal part of the fractured leg was accidentally turned almost 180° round its axis, and the parts of the skeleton united in such a position, most probably with considerable delay; an additional extremity developed in this case.

When additional formations develop after repeated bendings at the point of fracture or the skeleton, the healing of the injured parts of the tissues is retarded and enough time is allowed for the action of the decomposition products on the surrounding tissues and for the development of regenerative processes.

I have not fully determined what conditions are favourable for the development of additional formations during delayed healing of fractures and what peculiarities characterize their origin. Thisrequires further investigation. But, as I do not intend to return in the near future to the study of these problems, I limit myself to stating the above results.

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